

## TITLE

APPARATUS AND METHOD FOR GLASS  
SEPARATION FOR FLAT PANEL DISPLAYS

## CROSS REFERENCE TO RELATED APPLICATIONS (if applicable)

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH &  
DEVELOPMENT (if applicable)

Not applicable.

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## BACKGROUND OF THE INVENTION

The preferred embodiments of the present invention generally relate to a method and apparatus for separating glass panels such as those used in flat panel displays.

10 Liquid crystal displays or light imagers, such as those used in X-ray  
imaging systems, require the manufacture of circuitry on thin glass panels, for  
example comprising amorphous silicon transistors and photodiodes. The circuitry  
may range from as small as two centimeters to more than sixty centimeters on a side.  
Oftentimes, semiconductor devices are formed on the glass panel, making it even  
15 more difficult to handle the glass panels because touching the active area of the panel  
may result in damaging the semiconductor devices. Thus, in producing these panels,  
manufacturers often use a piece of glass with dimensions slightly larger than the final

product dimensions. Then, prior to completing the product, the extra edge portions of the glass panel are removed, resulting in a glass panel with the desired dimensions.

The separation process generally requires two steps. First, the original glass panel is scored, outlining the desired shape and size of the final glass panel. Once scored, the unwanted edges are separated along the scoring lines to achieve the final desired product dimensions. This panel separation process is typically done by manual separation. The manufacturer simply places the unwanted edges between his or her thumb and index finger and applies pressure to the unwanted edges until the glass separates. This conventional method does not allow the person separating the glass to provide a controllable amount of force evenly along the entire edge to be separated, thereby making it difficult to control the direction of the separation crack. Therefore, manual separation often results in defects within the final glass panel. These defects may even be visible to the naked eye, and can reduce the yield of the product. Furthermore, excessive handling of the glass panel may cause electrostatic damage (ESD) to the circuitry. A glass panel with x-ray imager structures formed on it can cost tens of thousands of dollars to produce, but can be completely ruined if not correctly separated. Thus, a more reliable method and apparatus are needed for separating the unwanted portions of glass.

A need exists for an improved method and apparatus for separating glass panels. The preferred embodiments meet this and other needs that will become more apparent from the following description and appended claims and drawings.

#### BRIEF SUMMARY OF THE INVENTION

A method and apparatus are provided for separating glass panels that provide more consistent separation and minimize separation defects in the glass panel. A preferred embodiment of the present invention includes a separation handle that applies the minimal pressure necessary to separate the glass evenly along the unwanted edge portions to be removed.

In a preferred embodiment, the scored panel is placed upon a stage, which is covered by an electrically dissipative material to prevent any electrostatic discharge from destroying the semiconductors etched in the glass panel. Nitrogen gas is pumped along the underside of the glass panel, causing the glass panel to float  
5 above the stage during positioning. Locating pins are inserted into holes located along the side of the stage to accurately position the panel. This allows successive glass panels to be placed in the same location on the stage, allowing for more consistent separation.

Once the glass panel is in place, a vacuum sucks the panel against the  
10 stage, holding the panel tightly against the stage. The separation handle is then inserted over the edge portion to be removed. A force gauge is attached to the separation handle to measure the amount of force applied to the glass panel. The force is incrementally increased until slow, controlled separation of the edge is achieved. The level of force is maintained until separation is complete. By using the  
15 minimal force in separating the glass, the likelihood of separation defects is greatly reduced. The stage is mechanically rotated without lifting or repositioning the glass panel before each subsequent separation, reducing the risk of ESD.

These and other features of the preferred embodiments of the present invention are discussed in the following detailed description of the preferred  
20 embodiments of the present invention. It shall be understood that other features and advantages will become apparent to those skilled in the art upon review of the following detailed description, drawings, and claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a scored glass panel prior to separation.

Figure 2 illustrates a schematic of a glass separating apparatus in  
25 accordance with a preferred embodiment of the present invention.

Figure 3 illustrates the components of the separation stage of a preferred embodiment of the present invention.

Figure 4 illustrates a separation handle in accordance with a preferred embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a glass panel 100, such as a glass panel used in liquid crystal displays or X-ray imagers. Such glass panels 100 may range in size, such as from about 2 to 60 centimeters on a side, and may range in thickness, such as from about 0.5 to 2 millimeters in thickness. Typical panels are made from the Corning Corporation's Code 7059 or Code 1737 glass. The original glass panel 100 used in the manufacturing process is larger than the final product, and thus the unwanted edges must be separated to produce a final product with desired dimensions. As seen in FIG. 1, the glass panel 100 is cut along score lines 110, thereby defining an inner panel 120 of desired dimension and edge portions 130, which are to be removed. The glass panel 100 may be scored with a diamond or tungsten carbide tool, and may be scored at anytime prior to the separation process.

FIG. 2 illustrates a glass separating apparatus 140 for separating the unwanted edge portion 130 of the glass panel 100. As shown, the glass separating apparatus 140 includes an electrically grounded positioner 150 for preventing any electrical discharge, a jig-slotted turntable 160, and a stage 170. The stage 170 is comprised of a base portion 180 that is covered by a charge dissipative material 190. In a preferred embodiment of the present invention, the base portion 180 is made of aluminum, while the charge dissipative material 190 is a polyacetal plastic alloy, such as Pomalax, which is available from Westlake Plastics in Lenexa, Pennsylvania.

During operation, the glass panel 100 is placed upon the glass separating apparatus 140. As mentioned above, semiconductor devices 200 may be formed on the glass panel 100. Since rubbing the glass panel 100 along the top surface of the separating apparatus 140 may cause electrostatic discharge that could damage semiconductor devices 200, nitrogen gas is pumped through channels 210 in the stage 170 along the entire underside of the glass panel 100. This causes the glass panel to float just above the surface of the charge dissipative material 190. For

simplicity only three channels 210 are shown in FIG. 3; however numerous channels 210 are similarly spaced along the entire surface of stage 170.

Once the glass panel 100 is floating above the separating apparatus 140, locating pins 220 are inserted in locating holes 230 in the side of the stage 170. In a preferred embodiment, three locating pins 220 are inserted into three different sides of the stage 170 to precisely locate the glass panel 100 above the separating apparatus 140. By using the same locating pins 220 in the same locating holes 230, each glass panel 100 will be located in the same position on the separating apparatus 140, thereby allowing easy automation of the separating process.

After locating the glass panel 100, the separating apparatus 140 switches from pumping nitrogen gas through the channels 210 to providing a vacuum for sucking the glass panel 100 tightly against the charge dissipative material 190. This vacuum keeps the glass plate 100 from sliding along the separating apparatus 140, which prevents any electrostatic discharge from damaging the semiconductor devices 200. As seen in FIG. 2, the outer portion of the glass panel 100, including the edge portion 130, is located outside the periphery of the separating apparatus 140. In a preferred embodiment, each of the four edge portions 130 is located outside the periphery of the separating apparatus 140 so that the user need only locate the glass panel 100 one time in order to remove all four edge portions 130, thereby reducing the risk of electrostatic damage while locating the glass panel 100. The stage 170 may be rotated without manual handling by motor 235 before each subsequent edge separation, to further reduce the chance of ESD. In a preferred embodiment of the present invention, a pedal 237 controls the action of the motor 235. By way of example, the score line 110 may extend about 0.1 to 1.5 millimeters past the stage 170, while the outer edge 240 of the glass plate 100 may extend 0.1 to 2.5 centimeters past the stage 170.

Turning to FIG. 4, a preferred embodiment of the present invention includes a separation handle 250 for removing the edge portion 130. The separation handle 250 includes slotted plate 260 attached to a handle 270. The slotted plate 260

also comprises an electrically dissipative material 280 to prevent electrostatic discharge on the surfaces in contact with the glass panel 100. In the preferred embodiment, the dissipative material 280 is identical to the charge dissipative material 190 on the stage 170.

5                   To separate one edge portion 130 from the inner portion 120, the edge portion 130 is inserted into the recess of the slotted plate 260. In the preferred embodiment, the slotted plate 260 should extend between 0.1 and 2.0 centimeters over the edge portion 130, and preferably within 0.1 millimeters from the score line 110. The person separating the glass panel then applies force to the handle 270. A force  
10                   gauge 290 is attached to the separation handle 250 to measure the force (F) applied to the handle 270, and in turn the edge portion 130. The force is incrementally increased until slow, controllable separation is achieved. This level of force is maintained until separation is complete. This allows the person separating the glass panel 100 to apply the minimal force necessary to complete separation. Since additional force may cause  
15                   defects within the glass, applying the minimal force minimizes the likelihood that defects will be present in the final product. Furthermore, the pressure is applied evenly along the width of the slotted plate 260, thereby causing a cleaner and more even break along the score line 110. This even pressure helps prevent sharp lips from forming on the bottom edge of the final product.

20                   Once the edge portion 130 of one side of the glass panel 100 is removed, the separating process is repeated for the remaining three sides. In the preferred embodiment, each of the remaining edge portions 130 is located outside the periphery of the separating apparatus 140 so that the glass panel 100 does not need to be relocated prior to removing the remaining three sides. The separating apparatus  
25                   140 is attached to a jig-slotted turntable 160 which allows the separating apparatus 140 to be mechanically rotated so that the user does not have to adjust his or her position in order to access the remaining sides. In the alternative, the separation process can be automated by applying the known separation force to each edge portion simultaneously or in turn.

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### Table 1

Figure 1 consists of 12 histograms arranged in a single row. Each histogram represents the distribution of the number of non-zero elements in the vector  $x$  for a specific value of  $n$ . The x-axis for all histograms is labeled 'x' and ranges from 0 to 120. The y-axis is labeled 'count' and ranges from 0 to 100. The histograms are labeled with their corresponding  $n$  values: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, and 120. As  $n$  increases, the distribution of  $x$  becomes more concentrated around zero, with the peak count increasing significantly.

It is evident from the above Table 1 that the tested glass panels were able to withstand a separation force in the range of 80-150 grams without producing any edge defects. It should be understood that this range of forces will vary depending on the type of glass used.

The second test included measuring the median vent depth along six segments of the separated edges and inspecting these edges for the loss of median vent. Once the edge portions were removed, the propagation edge was examined to determine the precise location of the median vent cracks along the top and bottom (x) and left and right edges (y) of the panel. Any large variation in this location could lead to defects within the final product. The following results show the consistency of the median vent, along with evidence that no median vent loss occurred:

**Table 2**

Segment	1	2	3	4	5	6	Median Vent loss?
Average depth (y) in microns	178	160	171	169	169	162	No
Average depth (x) in microns	124	137	132	132	123	116	No

Although it may appear that there is a variation in the test measurements, the measurements are in microns, and thus, these slight variations are minimal at best.

Finally several panels were scored and separated, and once separated, the final product was tested to determine if the separation process had lowered the flexural strength of the glass panel. This test included several different variables, such as the number of edges that were separated, the pressure applied during scoring, and whether the layers were deposited on the glass panel prior to separation. The results are shown in Table 3:



**Table 3**

	Group 1	Group 2	Group 3	Group 4
Edges Removed	1	2	1	2
Pressure at scoring (psi)	24	24	30	30
Layers deposited	1	0	0	1
Average Flexural Strength (psi)	20912	19503	21522	15111
Standard Deviation (psi)	2376	5135	2780	5414

These results, which show an average tensile strength of roughly 15,000 to 21,000 psi compare to the strength of an unseparated glass panel. These results prove that the separation process described herein does not increase the number of edge defects.

It is apparent from the previous description that the preferred embodiment of the present invention provides a novel system that satisfies the objectives and advantages set forth above. While particular elements, embodiments and applications of the present invention have been shown and described, it is understood that the invention is not limited thereto since modifications may be made by those skilled in the art, particularly in light of the foregoing teaching. It is therefore contemplated by the appended claims to cover such modifications and incorporate those features that come within the spirit and scope of the invention.